Exam: EVEN_SEM_ESE_25-26 | Course Year: FY B Tech | Show | Clear

Regular — Start Date : 6/20/0026 12:00:00 AM — Upto Date : 6/22/0026 12:00:00 AM

Backlog — Start Date : 6/20/0026 12:00:00 AM — Upto Date : 6/22/0026 12:00:00 AM

Subject List for Photo Copy

| Subjects |
|---|
| Engineering Mathematics - I |
| Basic Mechanical Engineering |
| Engineering Mathematics-II |
| Industrial Chemistry |
| Basic Electrical Engineering |

| Que | Que Marks | Obt. Marks |
|---|---|---|
| Q.1 A) | 5 | 5 |
| Q.1 B) | 5 | 5 |
| Q.1 C) | 5 | 5 |
| Q.1 D) | 5 | N |
| Q.2 A) | 5 | N |



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Question No. 1

Q1. A

Given,

$s(t) = 2t^3 - 15t^2 + 36t \quad , t \in [2,4]$

1) We can see that $s(t)$ is a polynomial equation, therefore this equation is continuous at $[2,4]$

2) Differentiable :- (D.w.r.t t)

$s'(t) = 6t^2 - 30t + 36$

we can see that the eqn is differentiable at $(2,4)$

3) $f(a) = f(b)$

To check this condition take

$a = 2$

$b = 4$

such that

$s(a) = s(2) = 2(2)^3 - 15(2)^2 + 36(2)$

$= 16 - 60 + 72$

$\therefore s(a) = 28$

for $s(b)$

$s(4) = 2(4)^3 - 15(4)^2 + 36(4)$

$= 128 - 240 + 144$

$s(4) = 32$

$\therefore s(a) \neq s(b)$

This eqn does not satisfy Rolle's theorem



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Acc to question if we apply rolles theorem

$f(c) \in [2,4]$

$f'(c) = 0$

i.e $s'(c) = 0$

$6c^2 - 30c + 36 = 0$

we get

$6c^2 - 30c = -36$

$6(c^2 - 5c) = -36$

$c(c-5) = -6$

we get roots

$c = 3$ & $c = 2$ → this cannot be the point

$\therefore$ c must be $\in (2,4)$

$\therefore$ at $c = 3$, this is the point where cat comes to rest

Q1. B. Given eqn :-

$p(t) = 2t^3 - 9t^2 + 12t \quad , t \in [1,3]$

1) $p(t)$ is polynomial eqn $\therefore$ It is continous at $[1,3]$

2) $p(t)$ is differentiable at $(1,3)$

$p'(t) = 6t^2 - 18t + 12$

$\therefore$ It satisfies LMVT conditions

3) for $f(a)$ & $f(b)$ i.e

$f'(c) = \frac{f(b) - f(a)}{b-a}$



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$f'(c) = p'(c) = 6c^2 - 18c + 12 \quad , c = 3,1$

$f'(c) = \frac{p(3) - p(1)}{3-1}$

$p'(c) = \frac{[2(3)^3 - 9(3)^2 + 12(3)] - [2(1)^3 - 9(1)^2 + 12(1)]}{2}$

$\therefore p'(c) = \frac{9-5}{2} = 2$

$\therefore 6c^2 - 18c + 12 = 2$

$6c^2 - 18c + 10 = 0$

we get $c = \frac{9 \pm \sqrt{21}}{6}$

$c_1 = \frac{9+\sqrt{21}}{6} = 2.263$

$c_2 = \frac{9-\sqrt{21}}{6} = 0.7362 \in$ This is not possible

$\therefore$ Instantaneous velocity equals avg velocity at 2.263 sec



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Q1 C) $f(x) = \frac{x}{x^2 - 7x + 10}$

By solving this, we get

$= \frac{x}{x^2 - 5x - 2x + 10} = \frac{x}{x(x-5) - 2(x-5)}$

$= \frac{x}{(x-5)(x-2)} \quad - (i)$

Now splitting this we get

$\frac{x}{(x-5)(x-2)} = \frac{A}{x-5} + \frac{B}{x-2} \quad - (ii)$

$x = A(x-2) + B(x-5) \quad - (iii)$

Denominators gets cancelled

Now we have to get values of A & B

1) To find A :-

putting $x = 5$, we get

$5 = A(5-2) + B(5-5)$

$A(3) = 5$

$A(5-2) = 5$

$\therefore A = \frac{5}{3}$

2) To find B :-

put $x = 2$, we get

$2 = A(2-2) + B(2-5)$

$2 = B(-3)$

$\therefore B = 2/-3 \quad \therefore B = \frac{-2}{3}$



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put values of A & B in eqn (ii)

$\frac{x}{(x-5)(x-2)} = \frac{5/3}{(x-5)} + \frac{-2/3}{(x-2)}$

$= \frac{5}{3}\left(\frac{1}{x-5}\right) - \frac{2}{3}\left(\frac{1}{x-2}\right)$

Using $n^{th}$ derivative formula :-

$\frac{1}{ax+b} = \frac{(-1)^n n! a^n}{(ax+b)^{n+1}}$



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Question No. 2

Q2 B) Given, $f(x) = 3x^3 + 7x^2 + x - 6$

expand in ascending powers of $(x+3)$

D.w.r.t x

$f'(x) = 9x^2 + 14x + 1$

$f''(x) = 18x + 14$

$f'''(x) = 18$

$f^{iv}(x) = 0$ ← this tells that we have to take till $f'''(x)$ for taylors theorem

Using this formula we get

$$= \frac{5}{3}\frac{(-1)^n n!\,1^n}{(x-5)^{n+1}} - \frac{2}{3}\cdot\frac{(-1)^n n!\,1^n}{(x-2)^{n+1}}$$

$$= \frac{1}{3}\times(-1)^n n!\,1^n\left[\frac{5}{(x-5)^{n+1}} - \frac{2}{(x-2)^{n+1}}\right]$$

$\therefore$ $n^{th}$ derivative of $\frac{x}{x^2-7x+10}$ is

$$= \frac{1}{3}\times(-1)^n n!\,1^n\left[\frac{5}{(x-5)^{n+1}} - \frac{2}{(x-2)^{n+1}}\right]$$

putting the value of $x = -3$, in eq's we get,

$f(3) = 3(3)^3 + 7(3)^2 + 3 - 6 = 81+63-3 = 141$ //

$f'(3) = 9(3)^2 + 14(3) + 1 = 124$ //

$f''(3) = 18(3) + 14 = 68$ //

$f'''(3) = 18$

Taylors theorem for ascending power in $(x+a)$:-

$$f(x) = f(a) + x f'(a) + \frac{x^2}{2!} f''(a) + \frac{x^3}{3!} f'''(a)$$

By putting the values we found in equation of taylors th^ we get :-

$$f(x) = 141 + x(124) + \frac{x^2}{2!}(68) + \frac{x^3}{3!}(18)$$

By simplifying we get, Taylors Th^m :-

$$f(x) = 141 + 124(x) + 34x^2 + 3x^3$$



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Question No. 3

(Q3 (B)) Given,

$$u = \tan^{-1}\left(\frac{x^3+y^3}{x^3y^3}\right)$$

put $x = tx$ & $y = ty$, we get

$$u = \tan^{-1}\left(\frac{t^3x^3 + t^3y^3}{t^3x^3 \cdot t^3y^3}\right)$$

$$u = \tan^{-1}\left(\frac{t^3(x^3+y^3)}{t^6(x^3y^3)}\right)$$

$$\tan u = \frac{t^3}{t^{36}}\left(\frac{x^3+y^3}{x^3y^3}\right)$$

we can find that

n = ~~value~~ degree of numerator − degree of denominator

$n = 3 - 6$

$\therefore n = -3$

For first order eulers theorem

$$x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = n.u$$

$$x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = -3\times\tan^{-1}\left(\frac{x^3+y^3}{x^3y^3}\right)$$



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for second order eulers theorem

$$x^2\frac{\partial^2 u}{\partial x^2} + y^2\frac{\partial^2 u}{\partial y^2} + 2xy\frac{\partial^2 u}{\partial x\,\partial y} = n.(n-1)\,u$$

$$= (-3)(-3-1)\tan^{-1}\left(\frac{x^3+y^3}{x^3y^3}\right)$$

$$\therefore x^2\frac{\partial^2 u}{\partial x^2} + y^2\frac{\partial^2 u}{\partial y^2} + 2xy\frac{\partial^2 u}{\partial x\,\partial y} = 12\tan^{-1}\left(\frac{x^3+y^3}{x^3y^3}\right)$$ //

In the power system field analysis it is used to measure the electric potential in Voltage.



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Question No 4

(Q4 (A)) we know that,

$V_m = 150$ units

Actual Volume will be $|J| \times V_m$

Given,

$x = 0.5u + 0.2v \Rightarrow x = 0.5u + 0.2v + 0w$

$y = 0.3u + 0.6v \Rightarrow y = 0.3u + 0.6v + 0w$

$z = 0.7w \Rightarrow z = 0u + 0v + 0.7w$

for x :-

$a_u = 0.5$

$a_v = 0.2$

$a_w = 0$

for y

$b_u = 0.3$

$b_v = 0.6$

$b_w = 0$

for z

$c_u = 0$

$c_v = 0$

$c_w = 0.7$

$$J = \begin{vmatrix} a_u & a_v & a_w \\ b_u & b_v & b_w \\ c_u & c_v & c_w \end{vmatrix}$$

$$= \begin{vmatrix} 0.5 & 0.2 & 0 \\ 0.3 & 0.6 & 0 \\ 0 & 0 & 0.7 \end{vmatrix}$$



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$$= 0.5(0.6\times0.7) - 0.2(0.3\times0.7) + 0$$

$$= 0.21 - 0.042$$

$\therefore J = 0.168$

$\therefore$ Actual volume = $|J| \times V_m$

$= 0.168 \times 150$

$= 25.2$ unit$^3$ cube

$= 25.2\ mm^3$

$\therefore$ Actual volume of kidney stone $= 25.2\ mm^3$

(Q4(B)) Given,

$$u = \frac{x-y}{1+xy}, \quad v = \tan^{-1}(x) - \tan^{-1}(y)$$

using formula $\frac{u}{v} = \frac{u'v - v'u}{v^2}$

For u,

$U_x$ (diff u w.r.t x only) $= \frac{1(1+xy) - (y)(x-y)}{(1+xy)^2}$

$= \frac{1+xy - xy + y^2}{(1+xy)^2}$

$= \frac{1+y^2}{(1+xy)^2}$

$U_y$ (diff u w.r.t y) $= \frac{(-1)(1+xy) - (x)(x-y)}{(1+xy)^2}$

$= \frac{-1-xy-x^2+xy}{(1+xy)^2}$

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$$U_y = \frac{-(1+x^2)}{(1+xy)^2}$$

for $v = \tan^{-1}(x) - \tan^{-1}(y)$

$$V_x = \frac{1}{1+x^2} \times 2x - 0 = \frac{2x}{1+x^2}$$

$$V_y = -\left(\frac{1}{1+y^2} \times 2y\right) = \frac{-2y}{1+y^2}$$

$\because \tan^{-1}(\theta) = \frac{1}{1+\theta^2}$ //

$$J = \begin{vmatrix} U_x & U_y \\ V_x & V_y \end{vmatrix}$$

$$= \begin{vmatrix} \frac{1+y^2}{(1+xy)^2} & \frac{-(1+x^2)}{(1+xy)^2} \\ \frac{2x}{1+x^2} & \frac{-2y}{1+y^2} \end{vmatrix}$$

$$= \frac{1+y^2}{(1+xy)^2} \times \frac{-2y}{1+y^2} - \left(\frac{-(1+x^2)}{(1+xy)^2} \times \frac{2x}{1+x^2}\right)$$

$$= \frac{-2y}{(1+xy)^2} + \frac{2x}{(1+xy)^2}$$

$$J = \frac{1}{(1+xy)^2}[2x - 2y]$$

$\therefore$ u & v are functionally independent
i.e. $J \neq 0$



Question No. 2

(Q2 D) $\lim_{x \to 0} \left(\frac{1}{x}\right)^{2x \sin x}$

$$y = \lim_{x \to 0} \left(\frac{1}{x}\right)^{2x \sin x}$$

putting log on both sides

$$\log y = \lim_{x \to 0} 2x \sin x \ln(1/x) = 0$$

$$= \lim_{x \to 0} \frac{2 \sin x \ln(1/x)}{\frac{1}{x}} = \frac{0}{0}$$

Using L - Hospital Rule
p.w.r.t x

Numerator $= 2x(x) + 2\ln(1/x)$

denominator $= -\operatorname{cosec} x \cot x$

Formula :- L - Hospital rule states that
if $a \quad f(x) = \lim_{x \to 0} \frac{n}{n} = \frac{0}{0}$
is in $\frac{0}{0}$ form then we can use L-Hospital rule to differentiate the function
It is also applicable for $\frac{\infty}{\infty}$ form



$$\lim_{x \to 0} \left(\frac{1}{x}\right)^{2x \sin x} = \frac{-3}{2}$$

(Q2 C) $y = \tan^{-1}\left(\frac{2x}{1-x^2}\right)$

put $x = \tan\theta \sin\theta$

$$y = \frac{2}{\text{Add2}} \tan^{-1}\left(\frac{2 \sin\theta}{1-\sin^2\theta}\right)$$

We know $\cos^2\theta = 1 - \sin^2\theta$

$$= \tan^{-1}\left(\frac{2 \sin\theta}{\cos^2\theta}\right)$$

$$= \tan^{-1}\left(\frac{2 \tan\theta}{\cos\theta}\right)$$

$$y = \frac{2}{\cos\theta} = 2 \sec\theta$$



Diff y

$y' = 2 \sec\theta \tan\theta$

$y'' = 2 \times (\sec\theta \tan^2\theta + \tan\theta \sec^2\theta)$

Maclaurin series in ascending powers of x

$$f(x) = f(a) + x f'(a) + \frac{x^2}{2} f''(a) + \dots$$

$$= 2 \sec\theta + x(2 \sec\theta \tan\theta) + \frac{x^2}{2}(2 \sec\theta \tan^2\theta + \tan\theta \sec^2\theta) + \dots$$

$\therefore$ Maclaurin series

$$f(x) = 2 \sec\theta + 2x \sec\theta \tan\theta + \frac{x^2}{2}(\sec\theta \tan^2\theta + \tan\theta \sec^2\theta) + \dots$$



Question No. 3

(Q3 A) Given $u = \tan^{-1}\left(\frac{y}{x}\right)$

Formula :-
Euler theorem
1st order :-

$$x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y} = n \cdot u(x,y)$$

2nd order :-

$$x^2 \frac{\partial^2 u}{\partial x^2} + 2xy \frac{\partial^2 u}{\partial x \partial y} + y^2 \frac{\partial^2 u}{\partial y^2} = n G(u)[G'(u) - 1]$$

$\tan(u) = \frac{y}{x}$



Diff u w.r.t x

$$\frac{\partial u}{\partial x} = \frac{1}{1+(y/x)^2} = \frac{y(-1)}{x^2(x^2+y^2)} \frac{1}{x^2} = \frac{(-1)x^2 y}{x^2 x^2 + y^2}$$

$$\frac{\partial^2 u}{\partial x \partial y} = \frac{\partial^2 u}{\partial y \cdot \partial x}$$

$\therefore$ It is proved that $\frac{\partial^2 u}{\partial x \partial y} = \frac{\partial^2 u}{\partial y \partial x}$

put $y = t \cdot y$ & $x = t \cdot x$

we get

$\tan(v) = \frac{y}{x}$

we can see that

n = degree of numerator − degree of denominator

$n = 1 - 1 = 0$

∴ 1st order :-

$x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y} = 0$



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Q3(B) Given

$u = \underbrace{\frac{x^2y^2z^2}{x^3+y^3+z^3}}_{a} + \underbrace{\sin\left(\frac{xy+yz}{x^2+y^2+z^2}\right)}_{b}$

Formula :-

Eulers theorem

$x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y} + z \frac{\partial u}{\partial z} = n \cdot u(x,y,z)$

for a

put $x = tx$, $y = ty$, $z = tz$

$a(tx, ty, tz) = \frac{t^{6+4}(x^2y^2z^2)}{t^3(x^3+y^3+z^3)}$

$n = 4$

$\therefore x \frac{\partial a}{\partial x} + y \frac{\partial a}{\partial y} + z \frac{\partial a}{\partial z} = 4 \frac{x^2y^2z^2}{x^3+y^3+z^3}$

for b

put $x = tx$, $y = ty$, $z = tz$

$b(tx, ty, tz) = \sin\left(\frac{t^2(xy+yz)}{t^2(x^2+y^2+z^2)}\right)$

$\therefore n = 0$

$\therefore x \frac{\partial b}{\partial x} + y \frac{\partial b}{\partial y} + z \frac{\partial b}{\partial z} = 0$



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Adding we get

$x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y} + z \frac{\partial u}{\partial z} = 4 \frac{x^2y^2z^2}{x^3+y^3+z^3}$



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Question No. 4

Q4C) $f(x,y) = x^3 + 3xy^2 - 3x^2 - 3y^2 + 4$

Formula :-

If $rt - s^2 > 0$, minima

If $rt - s^2 < 0$, $t > 0$, $r > 0$, maxima

If $rt - s^2 = 0$, eqn does not exist or have solution i.e eqn does not have min

$f'(x)$ (w.r.t x treating y constant)
:- $3x^2 + 3y^2 - 6x$

$U_y$ (treating x const")
$= 6xy - 6y = 6y(x-1)$



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Q4A) we know that

$V_m = 150$ volts

Actual voltage $\phi = |J| \times V_m$

Given,

$x = 0.5u + 0.2v + 0.w$

$y = 0.3u + 0.6v + 0.w$

$z = 0u + 0v + 0.7w$

for x :-

$a_u = 0.5$

$a_v = 0.2$

$a_w = 0$

for y

$b_u = 0.3$

$b_v = 0.6$

$b_w = 0$

for z

$c_u = 0$

$c_v = 0$

$c_w = 0.7$

$J = \begin{vmatrix} a_u & a_v & a_w \\ b_u & b_v & b_w \\ c_u & c_v & c_w \end{vmatrix}$

$= \begin{vmatrix} 0.5 & 0.2 & 0 \\ 0.3 & 0.6 & 0 \\ 0 & 0 & 0.7 \end{vmatrix}$

$= (0.5)(0.6 \times 0.7) - 0.2(0.3 \times 0.7)$

$= 0.21 - 0.042$



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$\therefore$ $J = 0.168$

$\therefore$ Actual Volume $= |J| \times V_m$

$= 0.168 \times 150$

$= 25.2\ mm^3$

$\therefore$ Volume of Kidney stone $= 25.2\ mm^3$



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$x^3 + 3xy^2 - 3x^2 - 3y^2 + 4$

$u_x = 3x^2 + 3y^2 - 6x = 3(x^2+y^2) - 6$

$u_y = 6yx - 6y + 0 = 6(xy - y)$

$xt - s^2 > 0$ maxima $r$, $t$

$xt - s^2$ minima $r <$

$\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v' - u(v)}{x^2}$

$y = \lim_{x \to 0} \left(\frac{1}{x}\right)^{2x \sin x}$

$\log y = \lim_{x \to 0} 2x \sin x \log\left(\frac{1}{x}\right)$



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Rough Work :-

Maclaurin = $f(a) + x f'(a) + \frac{x^2}{2!}(f''(a))$